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Artificial Fever Produced by High Frequency Currents

PRELIMINARY REPORT

From the Department of Neuro Psychiatry and Physiotherapy, Northwestern University Medical School and Cook County Psychopathic Hospital.

BY

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The work of Binger and Christie has shown that a temperature rise in the living tissue of animals can be produced by means of high frequency currents. They have also indicated that a slight rise in the general body temperature of animals has accompanied such experiments. It was our problem to determine whether a rise of 5-7 degrees F. could be produced in animals and man without injury to the subject. The end idea being to apply such artificial fever production to the treatment of general paresis and other infectious and chronic diseases.

The work of the above quoted authors concerned itself more with the general physiological viewpoint, while we were entirely concerned with raising body temperature to a desired level without tissue destruction. Binger and Christie have shown also that high frequency currents penetrate living tissues.

Our experiments were performed on dogs and men using a well known high frequency genera-

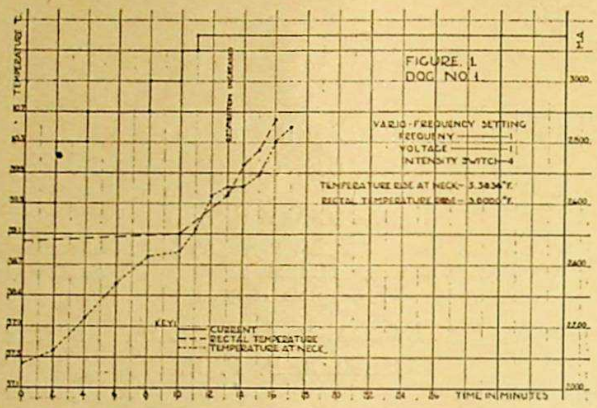

Fig. 1. Dog No. 1. Abrupt rise in temperature both in neck tissues and rectum to 40.6° C. Death through tissue coagulation four days later.

tor for the production of diathermy. Currents varying from 1000 to 4000 milliamperes were used.

Fourteen animals were used in our early experiments. Of these the first four died during the experiments or within the two following days. Postmortem examination showed coagulation of the tissue extending to a greater or less depth in the direct path of the current. Since the electrodes were uniformly applied to opposite sides of the abdomen and thorax this cooking of the tissue embraced the deep muscles of the back, the muscles of the abdomen and in some cases also caused a hemorrhagic exudate into the abdominal cavity. The internal temperature of some of the animals posted at death was so high that the operator could not bear to place the gloved finger under the loops of the intestines.

The department of pathology of Northwestern University Medical school will shortly publish a report on the macro and microscopic findings of the brain and spinal cords of these animals.

After these preliminary failures we slowly learned our mistakes. Too much current had been applied too rapidly. The next dog lived but showed extensive skin burns. We then began to enlarge our electrodes, using metal mesh instead of metal foil. Our animals lived longer, nevertheless there were two fatalities due to skin burns and coagulation. We were still in too great a hurry and pushed the current too much.

Next we changed our electrode to spongiopilene and stopped shaving the dogs. Since then all our dogs have lived with the exception of one ether death. In dogs a peculiar body condition exists which does not appertain to man. Dogs do not perspire. The electrode must therefore be kept wet in order to make a good conductor, otherwise burns result. Mesh electrodes and minute skin abrasions produce burns due to sparking and the lessened resistance of the area.

The size of the electrode must be equal and the distance between the electrodes as uniform as the contour of the subject permits. A large electrode on one side, a small one on the opposite side will probably produce burns under the smaller electrode. This is due to the greater density of current. About 100 square inches of spongiopilene for each electrode is sufficient for a forty pound animal.

With this we were able to apply 2500 milliamperes without injury. This approximates 25 to 30 milliamperes per square inch of electrode surface. The fatter and rounder the dog is the

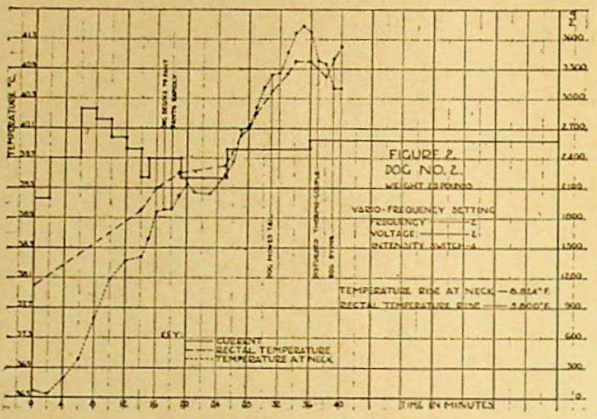

Fig. 2. Dog No. 2. Abrupt rise in temperature to 41.5° C. Rectal and tissue temperatures are finally equalized. Animal died.

more current can be applied per square inch without injury. The dogs averaged 6 inches in thickness. In man averaging double this in thickness more amperage can be applied per square inch. This is also due to better contact because of the perspiration response of the skin. We intend to give more accurate details in a future paper.

Procedure: The dogs were anesthetized, a thermocouple introduced into the deep muscles of the back and at right angles to the current or else into the deep muscles of the neck. In some experiments two thermocouples were used, one in each location. This procedure makes it possible to avoil the danger of coagulating the tissues beneath the electrodes. The galvanometer deflection method was used in recording the temperatures.

Rectal temperature was taken with the usual

clinical thermometer. Respiratory rate was taken in a few experiments. In the majority of the experiments readings were taken every two minutes.

The dogs were shaved until we found this to be an error owing to the impossibility of shaving the animal without some skin abrasions.

Electrodes used were first metal foil, then metal mesh, and later spongiopilene. There is still much room for improvement in electrode application in animal experimentation. Elec-

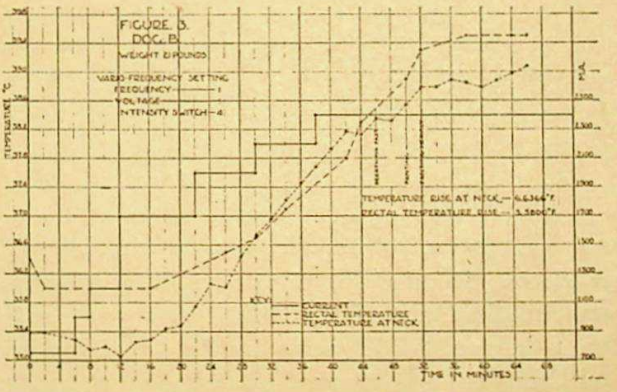

Fig. 3. Dog B. Gradual rise to 39.5° C. both in neck tissue and rectum. Animal lived.

trodes must be kept saturated with sodium chloride solution approximately of 2 per cent. concentration.

The current was raised gradually to a maximum to produce the desired temperature rise. By the use of a calibration chart the actual temperature in the region of the thermacouples could be readily secured.

The first curve, Fig. 1 (Dog 1) shows the re-

sult of too intense application of the current. The rise in temperature is very abrupt and proceeds to the coagulation point of the tissue. The

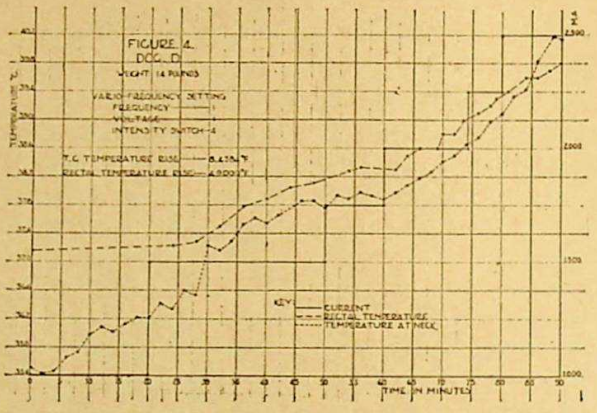

Fig. 4. Dog D. Gradual rise to 40.2° C. Animal lived.

time for a rise of 5.5 degrees F. was only 17 minutes. The dog died four days later. Thirty-one hundred and fifty milliamperes were used on a surface of fifty-five inches or fifty-seven milliamperes per square inch of dog weighing 14 lbs.

The second curve, Fig. 2 (Dog 2) shows a similar state of affairs. A rise of 9 degrees F. was reached in 40 minutes. In both curves a difference in the rectal and muscle temperature is noted at the start. These temperatures tend to approach each other as the rise occurs until the muscle temperature approximates that of the rectum. This dog died during the experiment and at this moment an abrupt rise of the rectal temperature is seen. The weight of this dog was 25 lbs.

The graph of the first dog which lived is shown in Fig. 3 (Dog B). The time consumed was now 66 minutes the maximum current was 2400 milliamperes and the current per square inch was 43 milliamperes. Extensive skin burns resulted because of the direct arcing through the interspaces of the mesh electrode.

The next graph, Fig. 4 (Dog 4), a light dog, weight 14 lbs. shows a gradual rise in temperature over a period of 90 minutes with a gradual increase in current from 1000 to 2500 milliamperes. A maximum of 45 milliamperes per square inch was used. This was the first animal on which spongiopilene was used. This was kept fairly wet. At the date of this report the dog is still alive and has recovered from a slight skin burn in fold between the right knees and abdomen.

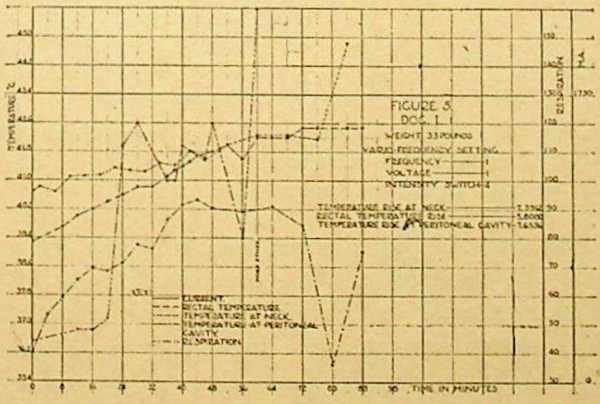

Fig. 5. Dog I. Temperature rise to 44.4° C. in neck tissues, corresponding to sudden drop in temperature of peritoneal cavity. Animal lived.

Figs. 5 and 6 show the graphs of our two final experimental animals. Dog I shows an in-

teresting and unexpected result. One thermocouple was placed in the peritoneal cavity while the other was inserted in the deep muscles of the neck. A sudden drop in peritoneal temperature occurred at the seventy-second minute corresponding to an equally abrupt rise of the neck temperature. This would seem to indicate a readjustment of the circulatory temperature load. Fig. 6 shows a typical rise in temperature in a large dog, weight 37 lbs. Here the electrodes

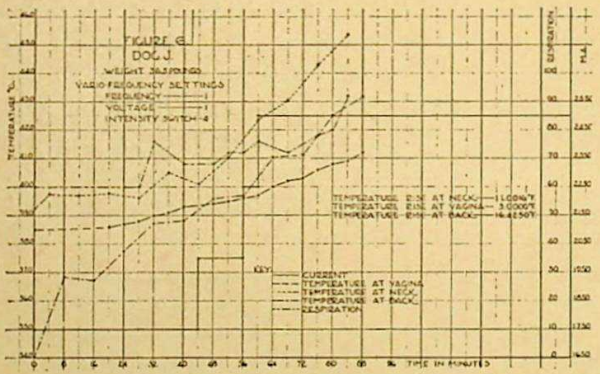

Fig. 6. Dog J. Gradual rise in temperature to 45.4° C. in neck tissues. Corresponding rise in muscles of the back and in the vagina. Animal lived.

had been enlarged to cover practically the entire body of the dog with the exception of the extremities, neck and head and a strip about 4 inches wide separating the two electrodes. Both these animals are alive and the last one shows no effects of the treatment whatsoever. In this animal 35 milliamperes per square inch of electrode were applied.

In Figs. 7 and 8 we submit our final graphs. Fig. 7 is of a normal individual who was treated

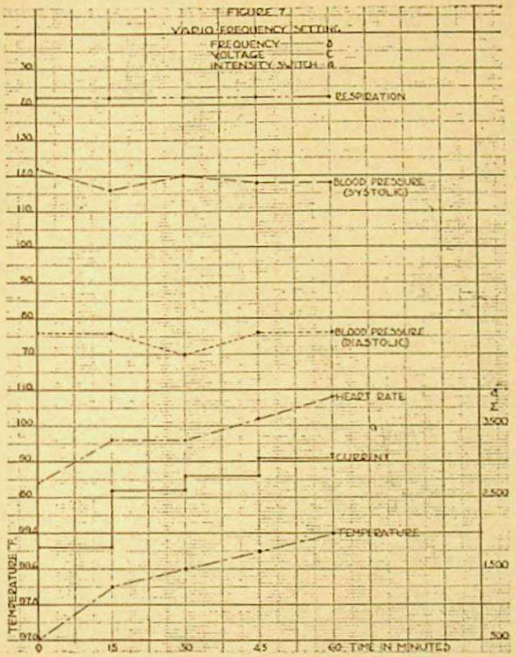

Fig. 7. Normal individual given up to 3000 milliamperes through chest and back, without insulation, for one hour. Temperature rise of 2.4° F.

without heat insulation through the ordinary metal electrodes. A rise of 2.4 degrees is recorded. The electrodes are now in the process of improvement and with them any temperature desirable can be obtained. Fig. 8, shows the temperature rise of 6° F. secured in a case of general paresis, the patient being still under treatment. We are not yet in a position to report on the clinical results of treatment. We have treated several patients with general paresis and intend to apply this method to the treat-

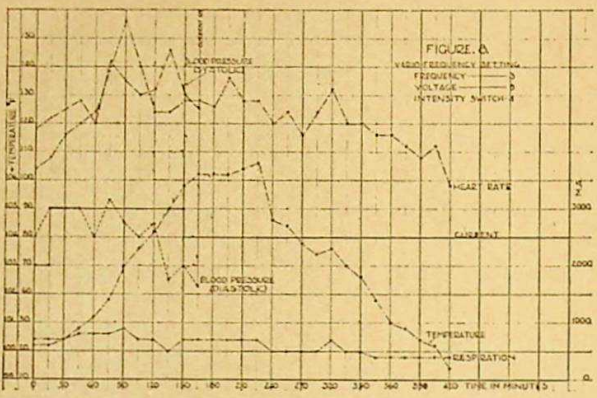

Fig. 8. Case of General Paresis. Given up to 3000 miliamperes through chest and back. Patient insulated with blankets. Rectal temperature rose to 106.1° F. in 2 hours and 45 minutes. After current was cut off a further rise to 106.6° F. was noted. Systolic blood pressure rose, diastolic fell. Temperature normal 4 hours and 15 minutes after treatment had ceased.

ment of primary syphilis and various acute and chronic infectious diseases.

CONCLUSIONS

1. Fever can be produced by high frequency currents.

2. Dangers from this form of treatment are encountered by too great and too sudden a density of current and improper contact between the body and the electrodes. These dangers can be largely overcome by perfected technique.

3. However, there may be another danger which cannot be obviated. The anatomical structure between the electrodes may be such that high densities of current are obtained causing probable high local rises in temperature. Whether these rises are above physiologic limits further experiment must determine.

We wish to extend our thanks to Mr. H. J. Holmquist, B. S. (M. E.) Secretary of the Council of Physical Therapy for his assistance in some of the physical problems.

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